


TELEDYNE HASTINGS


INSTRUCTION MANUAL INSTRUMENTS


MODEL HFM-60 FLOWMETER



 **TELEDYNE INSTRUMENTS**
Hastings Instruments
A Teledyne Technologies Company

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Manual Print History

The print history shown below lists the printing dates of all revisions and addenda created for this manual. The revision level letter increases alphabetically as the manual undergoes subsequent updates. Addenda, which are released between revisions, contain important change information that the user should incorporate immediately into the manual. Addenda are numbered sequentially. When a new revision is created, all addenda associated with the previous revision of the manual are incorporated into the new revision of the manual. Each new revision includes a revised copy of this print history page.

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The Hastings Mass Flowmeter, HFM-60 is designed to accurately measure mass flow up to 70 slpm with an accuracy of better than 3%. Hastings mass flow instruments do not require any periodic maintenance under normal operating conditions with clean gases. No damage will occur from the use of moderate overpressures (~150 psi) or overflows. Calibrations for other gases, such as oxygen, helium and argon, are available upon special order. Instruments are normally calibrated with the appropriate standard calibration gas (nitrogen) then a correction factor is used to adjust the output for the intended gas.

1.1 Features

- The HFM-60 is intrinsically linear. Should recalibration (a calibration standard is required) in the field be desired, the customer needs to simply set the zero and span points.
- The HFM-60 incorporates a removable/replaceable main PC board/sensor module which virtually eliminates long down time due to clogging. Clogging is the most common cause of failure in the industry. The HFM-60 sensor is less likely to be clogged due to the large internal diameter (0.020").
- Each flowmeter has a shunt which can be quickly and easily exchanged in the field to different ranges. Calibration, however, is required.
- The filters located upstream of the shunt and sensor eliminate most of the larger particulates and impurities which tend to clog the sensor tube.
- The HFM-60 is available in ranges from 0-10 sccm to 0-60 slpm (air equivalent flow). Special ranges are available upon request.
- The HFM-60 is constructed of 6061-T6 aluminum alloy. Buna-N is standard for the O-rings and seals. Other elastomers are available upon request, e.g., Kalrez, Viton.
- The temperature coefficient of the HFM-60 is less than 0.1%/°C from 0-50°C.
- The 4-20 mA option gives the user the advantages of a current loop output to minimize environmental noise pickup.
- The optional 0-90° tiltable digital display allows convenient real time indication of the flow rate.
- The low pressure drop across this instrument is ideal for leak detection applications.

1.2 Specifications

Accuracy	<±3% F.S.
Repeatability	±0.2% of F.S. (typical) ±0.4% of F.S. (max.)
Maximum pressure	150 psi.
Pressure coefficient	0.01%/psi (N ₂)
Operating temperature	0-50°C in non-condensing environment
Temperature coefficient (zero)	±1000 ppm/°C, typical (±2000 ppm/°C, max)
Temperature coefficient (span)	±500 ppm/°C, typical (±1000 ppm/°C, max)
Leak integrity	1x10 ⁻⁹ std. cc/s.
Standard Flow ranges	10, 20, 50, 100, 200, 500 sccm. 1, 2, 5, 10, 20, 40, 70 slpm.
Standard Output	0-5 VDC.
Optional Output	4 -20 mA.
Power	+15 to +25VDC, ≤60 mA (0 - 5VDC output). +15 to +25VDC, ≤80 mA (4-20 mA output).
Wetted Materials	6061 Al, 304L stainless steel, nylon, Buna N, Monel 400, Pb40Sn solder, (Cu30Zn brass in 40 to 60 slpm units, and epoxy in 10 to 200 sccm units)

1.3 Optional 4-20 mA Current Output

An option to the standard 0-5VDC output is the 4-20 mA current output that is proportional to flow. The 4 - 20 mA signal is produced from the 0 - 5VDC output of the flowmeter. The current loop output is useful for remote applications where pickup noise could substantially affect the stability of the voltage output. The load impedance should be between 0 and 400 Ω .

1.4 Digital Display (0-90° Tilttable)

1.4.1 Local Display

For real time indication of the flow rate, a very useful option available is a 3.5 digit LCD digital display module mounted directly on top of the flowmeter case. The display can be rotated 90° from the horizontal position to the fully vertical for better visibility. The LCD digits are large and clear and can be easily discerned at distances of 20 feet.

1.4.2 Remote Display

The tilttable display module may be removed from the flowmeter case and mounted at any distance away from the flowmeter body to permit convenient observation. Standard lengths of 7', 15' and 25' cable (also special orders of any desired length) are available.

1.5 Wall Transformer Power Supply

The input voltage required for operation of the flowmeter is +15 to +25VDC, at a maximum of 60 mA (80 mA for the 4-20 mA output option). A 115VAC wall power supply rectified to +18.5 VDC is available as a power supply option. The wall power supply comes with a 6' length of 2 conductor cable which can be connected directly to the HFM-60 connector.

1.6 Other Accessories

1.6.1 Totalizer (ATR-1J)

The Hastings Flow Totalizer integrates the 0-5VDC signal generated by the flowmeter to give a total flow reading. Count rates from 0 to 999 counts per minute are selectable by internal setting.

1.6.2 Hastings Model 400/200/40/10 Power Supply

Hastings power supplies (other than the aforementioned wall transformer) are available in either one, two or four channel versions. They convert 115 or 230VAC to the +15VDC required to operate the flowmeter. Interface terminals for the +15VDC input and the 0-5VDC linear output signal are located on the rear of the panel. Also, a cable can be supplied with the power supply that provides the +15VDC on pin 11 of a "D" connector and the 0 - 5VDC output measurement on pin 6. Pins 5 and 12 are common and pin 7 is chassis ground. Throughout this manual, when reference is made to a power supply, it is assumed the customer is using a Hastings wall power supply or a Model 200/400/40/10 supply.

This section contains the necessary steps to assist in getting a new flowmeter in operation as quickly and easily as possible. Please read the following thoroughly before attempting to install the instrument.

WARNING

The customer should determine if their process gas is compatible with the wetted materials of the flowmeter as specified in section 1.2. Some corrosive gases may damage the flowmeter materials and elastomer O-ring. This could result in incorrect flow measurement, or leakage over time.

2.1 Receiving and Inspection

Carefully unpack the Hastings HFM-60 and any accessories that have also been ordered. Inspect for any obvious signs of damage to the shipment. Immediately advise the carrier who delivered the shipment if any damage is suspected. Check each component shipped with the packing list. Insure that all parts are present (i.e., flowmeter, wall transformer power supply, cables, etc.). Optional equipment or accessories will be listed separately on the packing list. There may also be one or more OPT-options on the packing list. These normally refer to special ranges or special gas calibrations. They may also refer to special helium leak tests, high pressure tests or special modifications such as high temperature O-ring materials. In most cases, these are not separate parts, but special options or modifications built into the flowmeter.

2.2 Power Requirements

The HFM-60 requires +15 to +25VDC, 60mA (0 - 5VDC output); 80mA (4 - 20mA output). The supply voltage should be regulated such that there is no more than 50 mV ripple. Surge suppressors are recommended to prevent power spikes reaching the instrument. These power requirements are satisfied by the Hastings wall transformer or by the Hastings wall power supply described in Section 1.6.1 or 1.6.2.

2.3 Output Signal

The standard output of the flowmeter is a 0-5VDC signal proportional to the flow rate. The input power is applied at pins 1 (+15 to +25VDC) and 2 (ground). The output is obtained on pins 3 (0 to +5VDC) and 4 (common) of the 4 pin connector. It is recommended that the load resistance be no less than 2 k Ω . When the 4-20 mA option (see Section 1.3) is selected the output is also on pins 3 and 4. The load impedance must be no greater than 400 Ω .

2.4 Mechanical Connections

The flowmeter may be mounted in any position as long as the direction of gas flow through the instrument follows the arrow marked on the bottom of the flowmeter case label. The preferred orientation is with the inlet and outlet fittings in a horizontal plane. Changing the mounting orientation requires re-zeroing of the instrument at zero flow.

The smallest of the internal passageways in the HFM-60 is the diameter of the sensor tube, which is 0.020 and the annular clearance for the 500 sccm shunt which is 0.009", so the instrument requires adequate filtering of the gas supply to prevent blockage or clogging of the tube. The screen diffusers assist in filtering to some extent where the filter mesh is as small as 0.010".

There is a threaded hole in the bottom of the transducer that can be used to secure it to a mounting bracket, if desired. Other holes for special mounting can be added to the end cap as desired.

The standard inlet and outlet fittings for the HFM-60 are 1/4" NPT to 1/4" Swagelok (optional VCR and VCO fittings are available from the factory). The O-rings for the end cap and the sensor are Buna N (optional Kalrez, Neoprene or Viton O-rings are available from the factory). It is suggested that all connections be checked for leaks after installation. This can be done by pressurizing the instrument (do not exceed 150 psig unless the flowmeter is specifically rated for higher pressures) and applying a diluted soap solution to the flow connections.

2.5 Electrical Connections

If a wall transformer power supply from Hastings Instruments is used, installation consists of connecting the 4 conductor cable to the 4 pin connector located on the side of the flowmeter. The power is supplied to the instrument on pin 1, +15 to +25VDC, and pin 2, ground. The output is measured on pin 3, 0 - 5VDC or 4-20 mA and pin 4, ground. If a Hastings Model 400/200/40/10 power supply is used, installation consists of connecting a 4 conductor cable to the terminal strip on the rear of the supply to the 4 pin connector located on the side of the flowmeter (similar to that described above). Also, a cable with a male "D" connector can be supplied that mates with the power supply. The "D" connector cable provides +15VDC on pin 11 and the 0-5VDC output on pin 6. Pins 5 and 12 are common and pin 7 is chassis ground.

2.6 Operation

The standard instrument output is a 0 - 5VDC out and the signal is proportional to the flow i.e., 0 volts = zero flow and 5 volts = 100% of rated flow. The low noise 4 - 20 mA option is also proportional to flow (4 mA = zero flow and 20 mA = 100% of rated flow).

2.6.1 Operating Temperature

For proper operation, the combination of ambient temperature and gas temperature must be such that the flowmeter temperature remains between 0 and 50°C. Most accurate measurement of flow will be obtained if the flowmeter is zeroed at operating temperature as temperature shifts result in some zero offset.

2.6.2 Zero Check

Connect the wall transformer power supply to the instrument or if using a Hastings power supply, turn the power supply on. Allow approximately 10% flow for 1/2 hour warm-up. Stop all flow through the instrument and wait 2 minutes. **Caution:** Do not assume that all metering valves completely shut off the flow. Even a slight leakage will cause an indication on the meter and an apparent zero shift. For the standard 0-5VDC output, adjust the zero potentiometer located on the lower outlet side of the flowmeter until the meter indicates zero. For the optional 4-20 mA output, adjust the zero potentiometer so that the meter indicates slightly more than 4 mA, i.e. 4.03 to 4.05 mA. This slight positive adjustment ensures that the 4-20 mA current loop transmitter is not in its cut-off region. The error induced by this adjustment is approximately 0.3% of full scale. This zero should be checked periodically during normal operation. Zero adjustment is required if there is a change in ambient temperature, vertical orientation of the flowmeter, or a change in input voltage.

2.6.3 Blending of Gases

If more than one flowmeter is used to mix gases and each is calibrated for a given gas, a desired mixture of the gases can be achieved. As an example, suppose a total flow rate of 50 slpm of gases A+B+C is required; 15% of the total flow should be gas B, 20% of the total flow should be gas C and the balance is gas A. Then gas A should have a total flow of $0.65(50) = 32.5$ slpm, gas B should have a total flow of $0.15(50) = 7.5$ slpm and gas C should have a total flow of $0.20(50) = 10$ slpm. Further, let us say that flowmeter A has a 0-60 slpm range, flowmeter B has a 10 slpm range and flowmeter C has a 40 slpm range. Since all 3 flowmeters have 0-5 VDC out then flowmeter A should be set to read $5/60 = A/32.5$ or $A = 2.71$ volts, flowmeter B should be set to read $5/10 = B/7.5$ or $B = 3.75$ volts and flowmeter C should be set to read $5/40 = C/10$ or $C = 1.25$ volt. Ideally, however, flow controllers are a far better way to accomplish the blending, simply because there are no problems with pressure fluctuations.

2.6.4 Range Changes:

The range of the flowmeter can be changed in the field if recalibration facilities are available. The flowmeter may require a different shunt which can be purchased from the factory. A listing of available shunts (order codes) and the corresponding air equivalent flow ranges are as follows:

Order Code	Shunt Range	Order Code	Shunt Range
01	0-10 sccm	07	0-1 slpm
02	0-20 sccm	08	0-2 slpm
03	0-50 sccm	09	0-5 slpm
04	0-100 sccm	10	0-10 slpm
05	0-200 sccm	11	0-20 slpm
06	0-500 sccm	12	0-40 slpm
		13	0-70 slpm

Gases other than air or nitrogen have different properties, and the range of each shunt will be different than those listed in the order codes above.

The flow rate of interest determines the size of the shunt required. As previously indicated, 13 separate shunts are required for the range of flow spanning 10 sccm to 70 slpm full scale. For the 200 sccm flow range, four Monel 400 tubes of 0.027" i.d. are located within the aluminum shunt plug to accommodate the full 200 sccm. Lower flow rates require proportionally fewer tubes and the unused holes are sealed with epoxy (or selected eutectic solder if epoxy is undesired). A single 304L stainless steel plug with an annular spacing of 0.009" with the base accommodates the 500 sccm flow range. Increasing the flow requires more annular passageways which is accomplished by adding concentric cylinder shells with increasing gap dimensions. Eventually, a maximum annular gap dimension for laminar flow is obtained (~0.030"). For a maximum flow rate of 60 slpm, three annular regions using two brass concentric cylinders is required. To change ranges, a new shunt must be installed and a calibration conducted to do further measurements.

2.6.5 Spanning the Digital Display

An exchange of shunt requires resetting of the digital display. Ideally, the flow should be established to the full scale level consistent with the selected shunt and the display pot adjusted for that full scale flow rate. It is also possible to disconnect the phone jack connector to the main body and input 5.00VDC and set the display consistent with the particular full scale flow for the selected shunt. Verify the full scale voltage/current output and adjust the display pot for that full scale flow rate. It is also possible to disconnect the phone jack between the display and flowmeter, and supply external power (+5 VDC) and a full scale voltage (0-5 VDC) to the display. Refer to the schematics of PCB-846 in section 6 of this manual. The display may then be adjusted consistent with the particular full scale flow for the selected shunt. Note that there may be need to change the display board solder jumpers in order to exhibit the new full scale flow rate.

Largest Display Value	Jumper Setting
1999.	All jumpers open
199.9	JP 1 closed
19.99	JP 2 closed
1.999	JP 3 closed

Theory of Operation

This section contains an overall functional description of the HFM-60. Detailed schematics and parts lists can be found at the end of the manual in Section 5.0. In this section and other sections throughout this manual, it is assumed that the customer is using the wall transformer power supply supplied by Hastings or a Hastings Power Supply.

3.1 Overall Functional Description

The HFM-60 consists of a sensor, a base, shunt and electronic circuitry. The sensor measures the gas flow rate from 0 to 10 sccm. The shunt divides the flow such that the flow through the sensor is a precise percentage of the flow through the shunt. The flow through both the sensor and shunt is laminar. The circuit board amplifies the sensor output from the two Chromel P thermocouples and provides an analog output of either 0-5 VDC or 4-20 mA. The output can also be indicated on the digital display.

3.2 Sensor

The Hastings HFM-60 operates on a unique thermal electric principle whereby a metallic capillary tube is heated uniformly by a resistance winding attached at the center of the capillary (see figure 3.1). Thermocouples TC-1 and TC-2 are positioned on each side of the heater coil and are welded at equal distances from the mid-point of the capillary. At zero flow, the TC outputs are equal. When flow occurs through the tubing, heat is transferred from the heated region to the gas and from the gas back to the cool wall downstream. Thermocouple TC-1 measures the temperature upstream before the gas is heated and thermocouple TC-2 measures the gas temperature downstream after it is heated. During flow, the temperature distribution along the sensor tube becomes skewed (see figure 3.2). Conventionally, the difference in temperature of the two thermocouples provides a voltage difference that is proportional to flow.

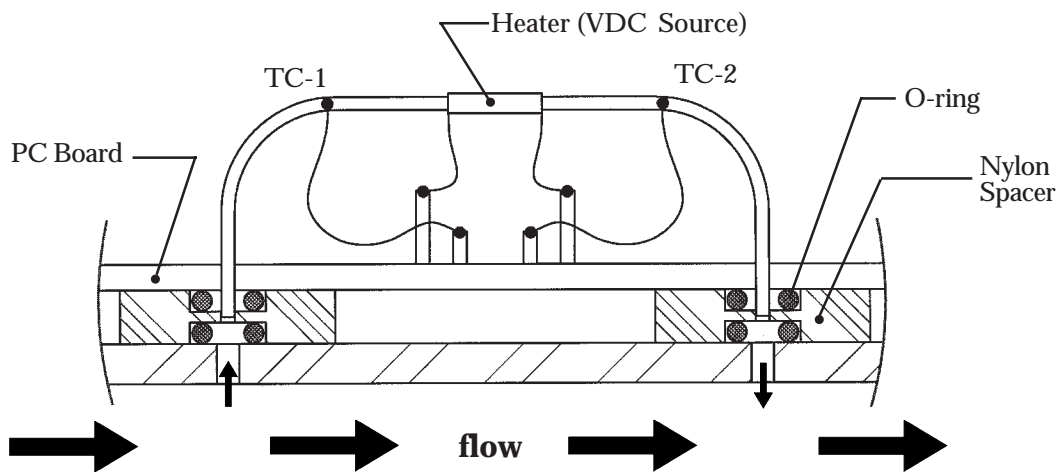


figure 3.1

For a constant power input, the differential voltage is a function of the mass flow rate and the heat capacity of the gas. Since the heat capacity of many gases is relatively constant over wide ranges of temperature and pressure, the flowmeter may be calibrated directly in mass units for those gases. Changes in gas composition usually require application of a multiplication factor to the air calibration to account for the difference in heat capacity. The flowmeter is capable of measuring a wide range of gases. The Monel 400 sensor tube has an internal diameter of 0.0205" and is heated by 600W of MWS-800 wire. This diameter allows approximately 10 sccm full scale flow with Δp of 0.5 inches of H_2O . The sensor is encapsulated by a plastic cover and filled with fiberglass insulation to minimize convective heat losses.

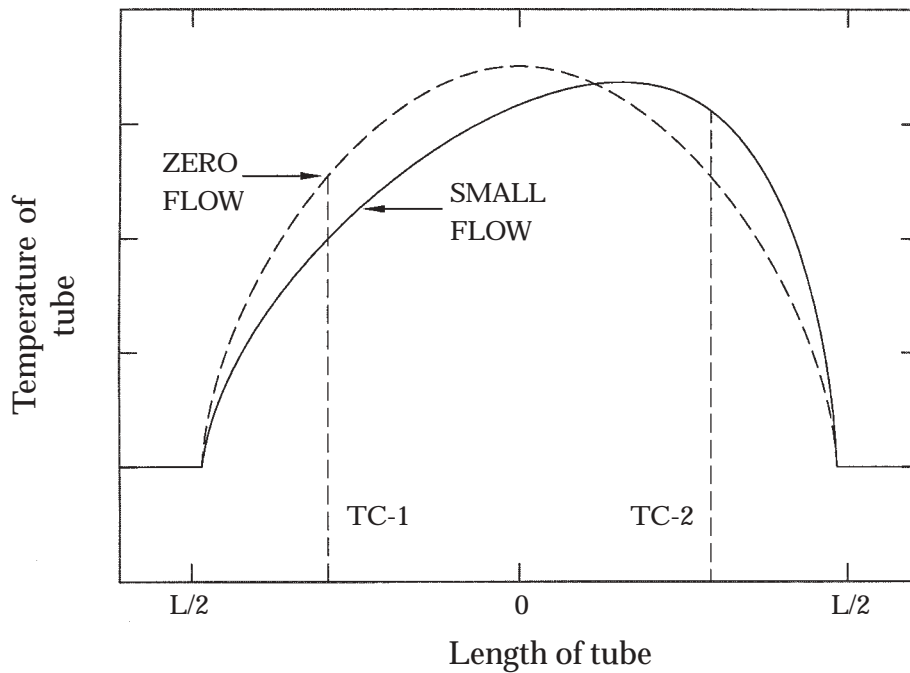


figure 3.2

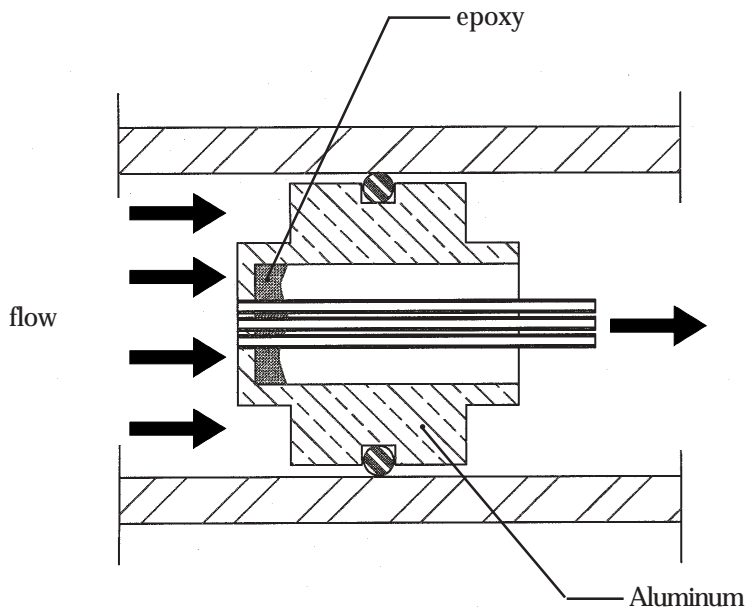
3.3 Base

The 6061 aluminum alloy base has a 1" square cross-section and is 3.375" long (with end cap). The internal flow channel is 0.812" diameter with in and out 304L stainless steel fittings 1/4" NPT to 1/4" Swagelok fittings.

3.4 Shunt

The flow rate of interest determines the size of the shunt required. As previously indicated, 13 separate shunts are required for the range of flow spanning 10 sccm to 70 slpm full scale. The geometry of the shunt for 0- 200 sccm is shown in figure 3.3(a). Four Monel 400 tubes of 0.027" i.d. are located within the aluminum plug to accommodate the full 200 sccm. Lower flow rates require proportionally fewer tubes and the unused holes are sealed with epoxy (or selected eutectic solder if epoxy is undesired). At the lowest flow rate (10 sccm), the shunt is completely blocked and all of the flow is routed through the sensor. Figure 3.3(b) shows the geometry for higher flow rates. A single 304L stainless steel plug with an annular spacing of 0.009" accommodates the 500 sccm flow range. Increasing the flow requires more annular passageways which is accomplished by adding concentric cylinder shells with increasing gap dimensions. Eventually, a maximum annular gap dimension for laminar flow is obtained (~0.030"). For a maximum flow rate of 70 slpm, three annular regions using two brass concentric cylinders is required. This patent pending shunt technology also includes inboard sensor ports which ensure laminar flow without the turbulence associated with end effects. This unique flow geometry provides an exceedingly linear shunt.

A schematic diagram of the integral flowmeter (without the digital display module) employing a 70 slpm shunt is shown in figure 3.4. Note the inboard location of the sensors inlet and outlet with respect to the inlet and outlet of the shunt. Also note the screen disk and washer which are used to minimize the radial velocity gradient entering the shunt. This results in a more uniform flow velocity profile and therefore, more uniform flow in the annular passages of the shunt.



**10 sccm - 200 sccm
(typical configuration)**

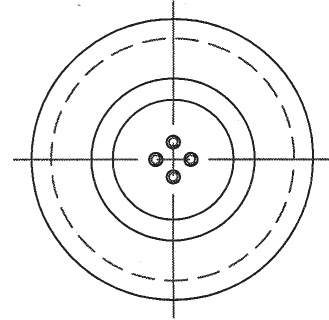
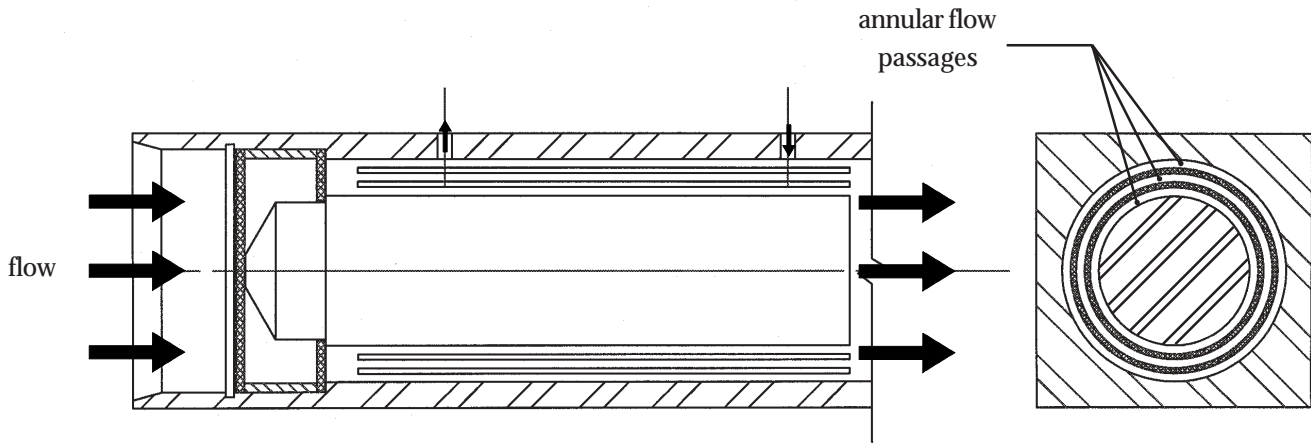


figure 3.3 (a)



**500 sccm - 70 slm
(typical configuration)**

figure 3.3 (b)

3.5 Electronic Circuitry

The HFM-60 employs a thermal flow sensor (capillary tube described in section 3.2) to measure the flow which is proportional to the total flow through the instrument. The sensor develops a differential voltage output signal proportional to flow which is approximately 1 mV full scale magnitude. A differential amplifier and an inverting amplifier boost the signal strength by a factor of ~5000 at full scale flow. The amplified output can be measured on pins 3 and 4 of the external connector. If a Hastings power supply is employed, the 5 volt output is also sent to the terminals on the back and to the decoding circuitry in the display which converts it to a 3 and 1/2 digit output. An optional 4-20 mA analog output on pins 3 and 4 is also available **in lieu of** an output voltage. The addition of a 4-20 mA current loop transmitter on the secondary pc board (mounted parallel to the main pc board) is required to provide this current loop. A jumper change is made on the main PC board to establish the selected output mode. The digital display option includes the tiltable LCD display module which is removable for remote display. This separate module contains its own pc board and mounts directly on the top of the main cover. This local or remote digital unit provides a continual digital display in addition to the 0-5VDC or 4-20 mA output. A standard 4 conductor phone jack and cable is used to connect the display module to the main pc board. The circuit diagrams for the aforementioned functions are presented in Section 6.

This section contains service and calibration information. Some portions of the instrument are delicate. Use extreme care when servicing the instrument. The potentiometer positions and the electrical components referred to in the troubleshooting section can be found in Section 4.3 on the electrical component layout drawing.

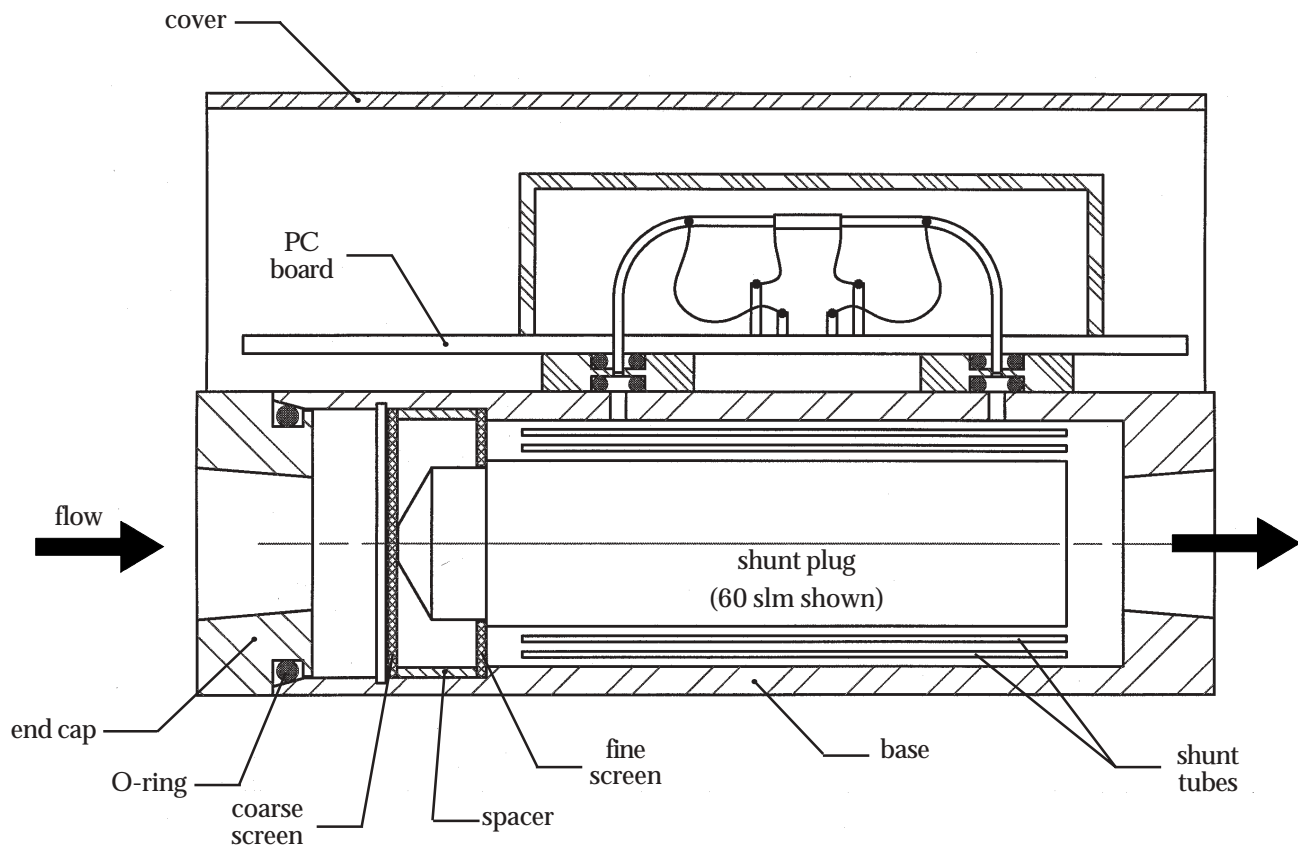


figure 3.4

4.1 Authorized Maintenance

With proper care in installation and use, the flowmeter will require little or no maintenance. If maintenance does become necessary, most of the instrument can be cleaned or repaired in the field. Some procedures may require recalibration. Do not attempt these procedures unless facilities are available. Entry into the sensor or tampering with the printed circuit board will void warranty. Do not perform repairs on these assemblies while the unit is still under warranty.

4.2 Troubleshooting

Symptom: Output reads strong indication of flow with no flow present. Zero pot has no effect.

Cause: Power shorted out.

Action: Unplug power supply for a few seconds, then plug it back in. If this is ineffective, disconnect the power supply from the unit and check the power supply voltage (+15 to +25 VDC on pin 1).

Symptom: Output of flowmeter is proportional to flow, but extremely small and not correctable by span pot.

Cause: Sensor is not being heated.

Action: Shut off gas supply and disconnect the power to the flowmeter. Remove cover and pc board from unit. Check the resistance between w1 and w2 on PCB-844 (refer to figures in section 6) of the flowmeter. The resistance should be approximately 560 Ω . The resistance between w3 and w4 should be approximately 2-3 Ω . If not, the sensor unit needs to be replaced.

Symptom: Sensor has proper resistance readings, but little or no output with flow.

Cause: Plugged sensor.

Action: Shut off gas supply and disconnect the power to the flowmeter. Remove cover and pc board from unit. If sensor has evidence of clogging, clean or replace as applicable.

Symptom: Flowmeter reads other than 0.00 VDC with no flow or there is a small flow when the flowmeter reads 0.00 VDC.

Cause: Zero pot is out of adjustment.

Action: Shut off all flow. For the standard 0-5VDC output, adjust the zero potentiometer located on the lower outlet side of the flowmeter until the meter indicates zero. For the optional 4-20 mA output, adjust the zero potentiometer so that the meter indicates slightly more than 4 mA, i.e. 4.03 to 4.05 mA. This slight positive adjustment ensures that the 4-20 mA transmitter is not in its cut-off region. The error induced by this adjustment is approximately 0.3% of full scale.

Symptom: Flowmeter is out of calibration and non-linear.

Cause: Leaks in the gas inlet or outlet fittings.

Action: Check all fittings for leaks by placing soap solution on all fittings between gas supply and final destination of gas. Check flowmeter for leaks. Replace "O"-rings if required or recalibrate as necessary.

4.3 Adjustments

Calibration Procedure (See figure 4.1)

1. Connect power to pins 1 and 2 as specified in Section 2.5. Allow the instrument to warm up for 30 minutes with 10% flow.
2. Completely shut off the flow and wait for 2 minutes. For the standard 0-5VDC output, adjust the zero potentiometer located on the lower outlet side of the flowmeter until the meter indicates zero. For the optional 4-20 mA output, adjust the zero potentiometer so that the meter indicates slightly more than 4 mA, i.e. 4.03 to 4.05 mA. This slight positive adjustment ensures that the 4-20 mA transmitter is not in its cut-off region. The error induced by this adjustment is approximately 0.3% of full scale.
3. Turn on gas supply to inlet of instrument and insure the flow rate is an accurate maximum flow for the shunt employed. Ensure that the full range can still be obtained at minimum inlet pressure.
4. Adjust Span pot until the flow reference reads full scale (5.00VDC or 20 mA). Perform this step only if a calibrated reference flowmeter is available.
5. Adjust the span pot of the display so that it reads correct full scale flow.
6. Record flowmeter and flow reference outputs for flow rates of 20%, 40%, 60%, 80% and 100% and make sure data are within $\pm 3\%$ of full scale.

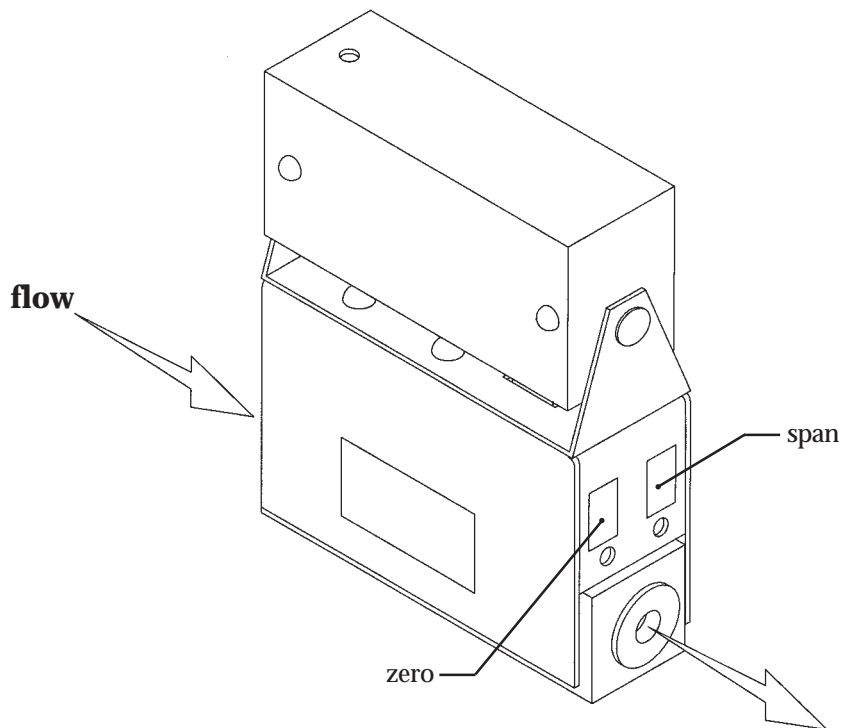


figure 4.1

4.4 End Cap Removal

The end cap on the inlet side must be removed to gain access to the filter and shunt assembly. First remove power and shut off the supply of gas to the instrument. Disconnect the Swagelok fittings on the inlet and outlet sides of the transducer and remove it from the system plumbing. Remove the two Allen head screws holding the end cap to the instrument (see figure 4.2). Carefully remove the end cap, retaining ring, filter, spacer, filter washer and ball bearing (if present) and shunt, noting their order and proper orientation. The shunt can be severely damaged if dropped. Examine the filter and shunt. If either is damaged, dirty or blocked, clean and replace as applicable. Reassemble in the reverse order of disassembly. Secure the endcap with 4 in lb of torque on each 18-8 stainless steel socket head cap screw. Use of a fastener other than the one mentioned here may result in leakage at the seal. **Recalibration of the HFM-60 is necessary.**

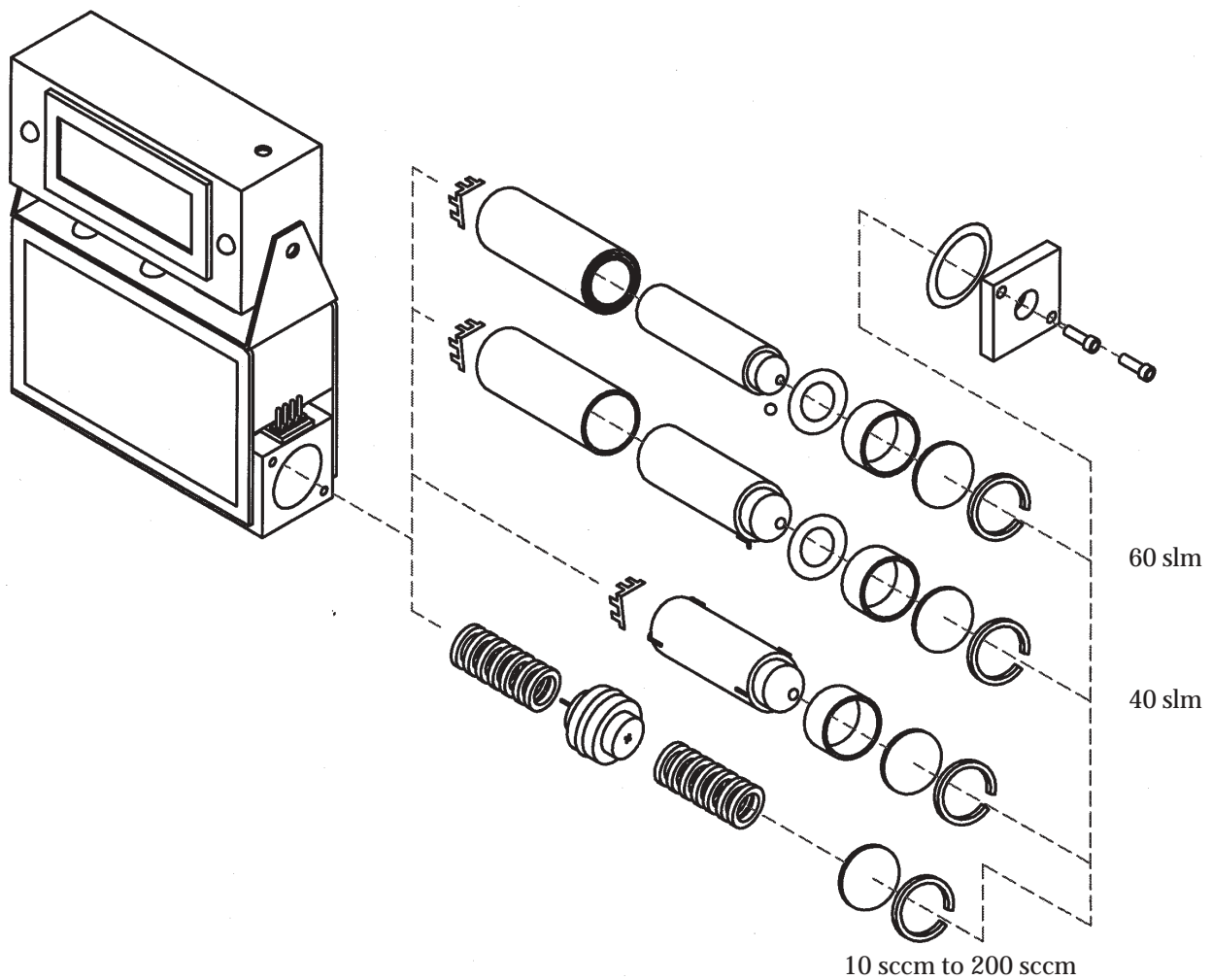


figure 4.2

4.5 Printed Circuit Board Replacement

In the event that any of the PC boards fail, they are easily removed from the instrument and replaced with a spare. This ease in disassembly and replacement substantially reduces instrument downtime.

1. Replacement of the 4-20 mA option PC board: Unplug the power cable from the transducer. If a digital display exists, unplug the phone jack connection and remove the flowmeter cover. Remove the 4 brass spacers and lift off the 4-20 mA board. Be careful not to damage the main board and 4-20 mA board connector.
2. Replacement of the main PC board: Continue from 1. Remove the 4 brass spacers from the main board and gently lift the board from the flowmeter base. When installing the replacement board, insure that the brass spacers are uniformly and securely tightened (finger tight) since the compression seals the "O"-rings on the base, PC board and the sensor tube which, in turn, maintains the integrity of the flow in the sensor.

4.6 Sensor Replacement

The sensor is an intimate part of the main PC board and can not be separately removed from the main board without great difficulty. Therefore, sensor replacement requires the replacement of the entire main board. Follow instructions for removing the main board as shown in Section 4.5 and consult Section 5 to acquire a new main board/sensor unit.

5.1 Warranty Repair Policy

Hastings Instruments warrants this product for a period of one year from the date of shipment to be free from defects in material and workmanship. This warranty does not apply to defects or failures resulting from unauthorized modification, misuse or mishandling of the product. This warranty does not apply to batteries or other expendable parts, nor to damage caused by leaking batteries or any similar occurrence. This warranty does not apply to any instrument which has had a tamper seal removed or broken.

This warranty is in lieu of all other warranties, expressed or implied, including any implied warranty as to fitness for a particular use. Hastings Instruments shall not be liable for any indirect or consequential damages.

Hastings Instruments, will, at its option, repair, replace or refund the selling price of the product if Hastings Instruments determines, in good faith, that it is defective in materials or workmanship during the warranty period. Defective instruments should be returned to Hastings Instruments, **shipment prepaid**, together with a written statement of the problem and a Return Material Authorization (RMA) number. Please consult the factory for your RMA number before returning any product for repair. Collect freight will not be accepted.

5.2 Non-Warranty Repair Policy

Any product returned for a non-warranty repair must be accompanied by a purchase order, RMA form and a written description of the problem with the instrument. If the repair cost is higher, you will be contacted for authorization before we proceed with any repairs. If you then choose not to have the product repaired, a minimum will be charged to cover the processing and inspection. Please consult the factory for your RMA number before returning any product repair.

TELEDYNE HASTINGS INSTRUMENTS

804 NEWCOMBE AVENUE

HAMPTON, VIRGINIA 23669 U.S.A.

ATTENTION: REPAIR DEPARTMENT

TELEPHONE (757) 723-6531

1-800-950-2468

FAX (757) 723-3925

EMAIL hastings_instruments@teledyne.com

INTERNET ADDRESS <http://www.hastings-inst.com>

Repair Forms may be obtained from the "Information Request" section of the Hastings Instruments web site.

COPYRIGHT 2002 TELEDYNE HASTINGS INSTRUMENTS ALL RIGHTS RESERVED	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES DECIMALS ARE .0010 FRACTIONS ARE 1/64 ANGLES ARE .125 .0010 .0010	ITEM(S)	65-748	REVISIONS	
		REV	F	REVISED PER ECN #1600	DATE
					04/01/02 C.R. COLE

ASSEMBLY NOTES

- ASSEMBLE AND CLEAN BOARDS IN ACCORDANCE WITH IPC-A-610 CLASS 2 STANDARDS.
- INSURE THAT JUMPERS JP1 AND JP2 ARE NOT SOLDER SHORTED DURING ASSEMBLY.
- W1 - W4 ARE NOT INSTALLED.

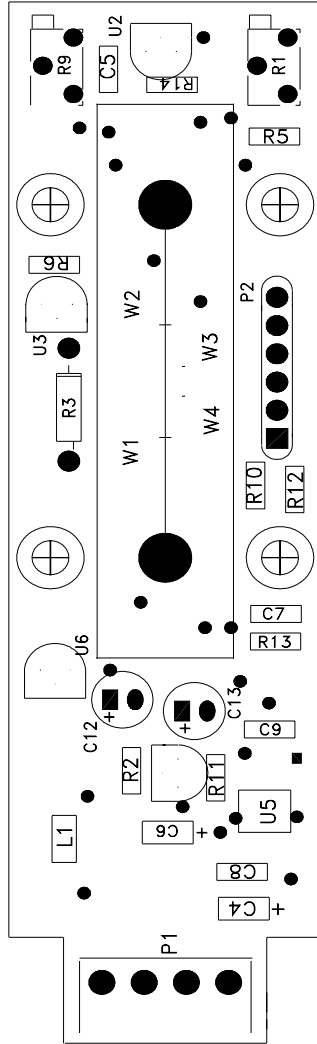
ITEM NO.	QTY	FSCM RECD NO.	PART OR IDENTIFYING NO.	DESCRIPTION	REF /DWG NO.
22	1		56-07-001	OP-AMP, AD706AR, SOIC-8	U5
21	8		11-08-128	CAP. CERAMIC, .1uf, ECU-V1H104KBW, SM cc1206	C2,C3,C5,C7,C8,C9,C10,C11
20	3		11-03-175	CAP. TANTALUM, .1uf, ECS-T1VX105R, SM tc3528	C1,C4,C6
19	2		11-03-170	CAP. ALUM ELECTR RAD LD, 10uf 50WV ECE-A1HU100	C12,C13
18	3		56-02-076	VOLT REG, POS ADJ LM317LZ, TO92	U1,U2,U6
17	1		56-02-098	VOLT REG, NEG ADJ LM337LZ, TO92	U3
16	1		19-05-074	POT.10K 1/4" SQUARE SIDE ADJUST BOURNS 3766X-1-103	R1
15	1		19-02-141	POT, 250K 1/4" SQUARE SIDE ADJUST, BOURNS 3266X-1-254	R9
14	2		18-01-447	RES, 1.02K 1/8 WATT 1%, PANASONIC ERJ-8ENF1021V, SM 1206	R10,R12
13	1		18-01-449	RES, 4.53K 1/8 WATT 1%, PANASONIC ERJ-8ENF4531V, SM 1206	R11
12	3		18-01-448	RES, 150K 1/8 WATT 1%, PANASONIC ERJ-8ENF1503V, SM 1206	R8,R13,R7
11	1		18-01-453	RES, 97.6K 1/8 WATT 1%, PANASONIC ERJ-8ENF9762, SM 1206	R14
10	1		18-01-450	RES, 487 1/8 WATT 1%, PANASONIC ERJ-8ENF4870V, SM 1206	R2
9	1		40-01-011	TEMP.1.2K 7000 PPM/C AXIAL LD,QUAL THERMISTOR QTG12-122J	R3
8	3		18-01-433	RES, 243 1/8 WATT 1%, PANASONIC ERJ-8ENF2430V, SM 1206	R4,R5,R15
7	1		18-01-451	RES, 2.61K 1/8 WATT 1%, PANASONIC ERJ-8ENF2611V, SM 1206	R6
6	1		18-01-452	RES, 1.74K 1/8 WATT 1%, PANASONIC ERJ-8ENF1741V, SM 1206	R16
5	1		56-02-106	VOLTAGE INVERTER 1.5-12 VDC	U7
4	2		13-01-171	RECT. HIGH SPEED SWITCHING BAS21 DIODES INC. BAS21LT1,SOT-23	D1, D2
3	1		16-04-060	4 POS. PIN STRIP, WECCO 931-SLS/16	P1
2	4		17-01-066	INDUCTOR, 100uH 80mA, MURATA LQH31T01K04, CC1210	L1, L2, L3, L4
1	1		26-04-844C	PCB, PC-844 BARE ETCHED BOARD	31216
ITEM NO.	QTY	FSCM RECD NO.	PART OR IDENTIFYING NO.	DESCRIPTION	REF /DWG NO.

TELEDYNE Hastings Instruments	ASSEMBLY DIAGRAM PCB 844	DRAWN R.B.MILLER 1/97 CHECKED T. QUINN 1/97	SCALE NONE SHEET 1 OF 3	PARTS LIST	SIZE B DWG. NO. 31212 REV F
					REF /DWG NO.

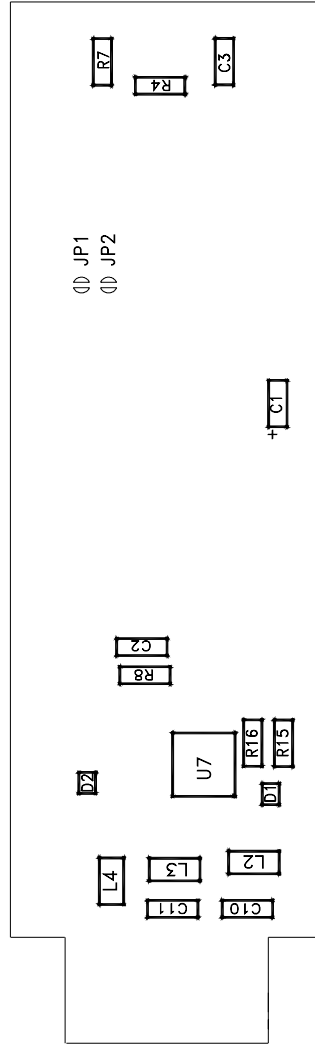
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DIMENSIONS ARE IN INCHES
FRACTIONS DECIMALS ANGLES
+ 1/64 .xxx.01 ± 2°
.xxx.005

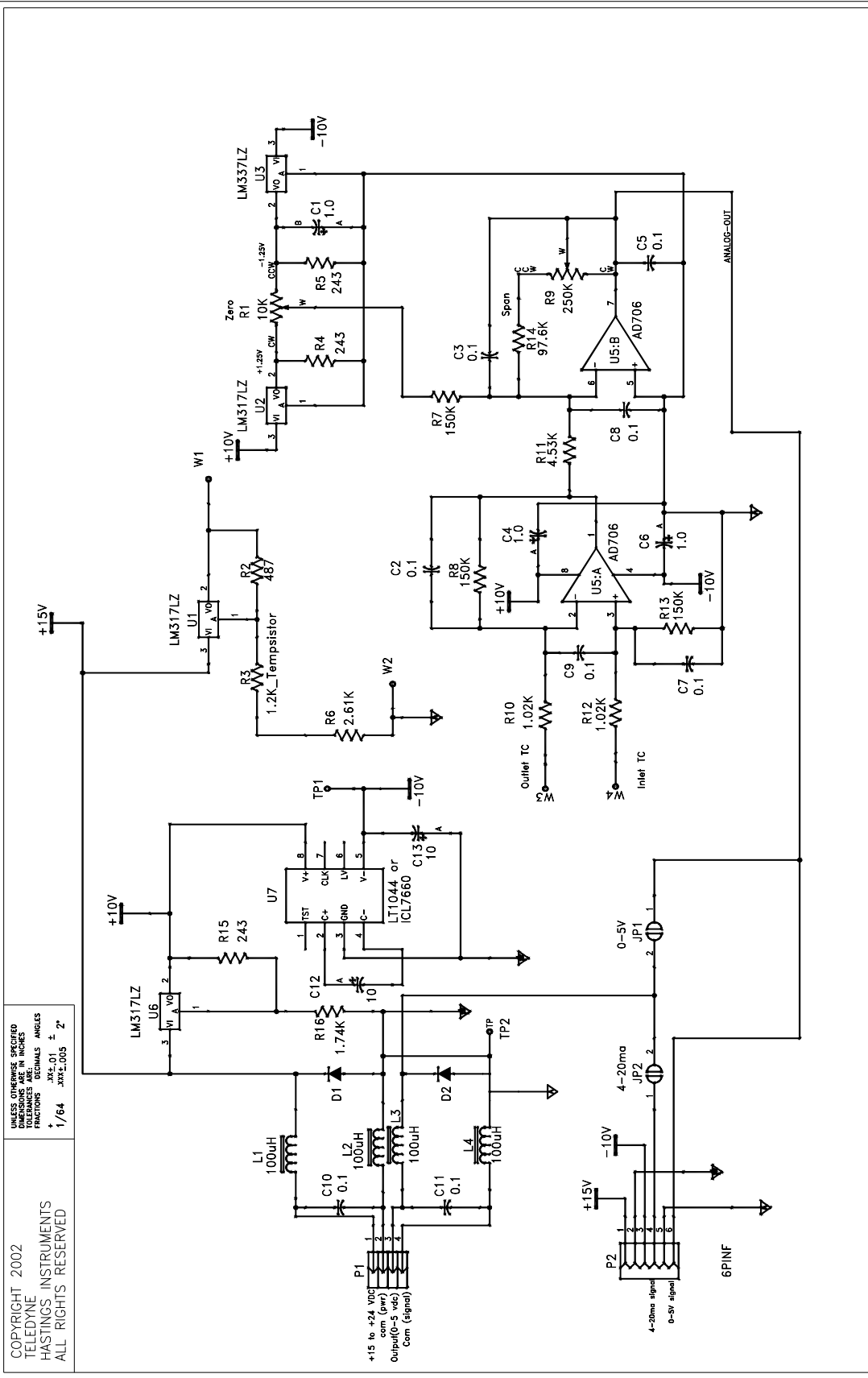


TOP VIEW PCB



BOTTOM VIEW PCB

TELEDYNE Hastings Instruments	ASSEMBLY DIAGRAM PCB 844		DRAWN R.B.MILLER 1/97	SCALE NONE	SIZE B	DWG. NO. 31212	REV F
			CHECKED T. QUINN 1/97	SHEET 2 of 3			



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 DIMENSIONS ARE IN INCHES
 FRACTIONS DECIMALS ANGLES
 .XXX2.01 ±
 1/64 .XXX2.005 2°

DRAWN R.B.MILLER CHECKED T. QUINN	SCALE 1/97	SCALE NONE	SIZE B	DWG. NO. 31212	REV F
	ASSEMBLY DIAGRAM PCB 844	SHEET 3 OF 3			

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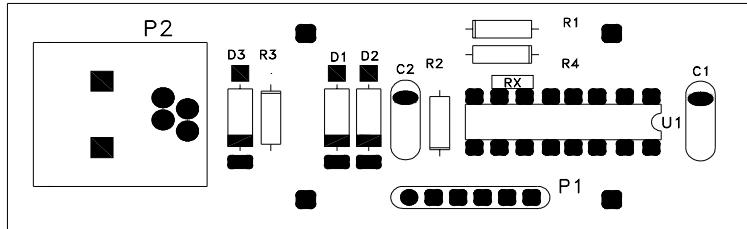
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DIMENSIONS ARE IN INCHES
FRACTIONS DECIMALS ANGLES
↑ 1/64 .001 .005 ° 2"

ITEM(S) 65-749

REVISIONS

REV	DESCRIPTION	ISSUED BY
C	REVISED PER ECN # 1363	



ASSEMBLY NOTES:

1. ASSEMBLE IN ACCORDANCE WITH IPC-A-610, CLASS 3 STANDARDS.
2. ITEM U1 IS NOT INSTALLED ON THIS ASSEMBLY.
3. ITEM P1 IS TO BE INSTALLED ON THE SOLDER SIDE OF THE PCB.
4. RESISTOR RX (ITEM 10) IS TO BE INSTALLED ON THE PADS FOR PINS 6 AND 7 OF U1 MAKING SURE TO ALLOW ENOUGH ROOM TO INSTALL U1 AT A LATER TIME.

ITEM NO.	QTY	FSCM RECD NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	REF/DWG NO.
10	1		18-01-476	RESISTOR	RX
9	2		11-01-159	CAP. CERAMIC .1uf 50V CRL, CENTRALAB CY20C104M	CT.C2
8	1		18-01-167	RES. 15K 1/8 OR 1/4 WATT 1%	R1
7	1		18-01-272	RES. 10K 1/8 OR 1/4 WATT 1%	R4
6	1		13-01-165	DIODE, SD101C SCHOTTKY BARRIER, ITT/DIODES INC. SD101CCT	D1
5	2		13-01-149	DIODE, 5.1 VOLT ZENER, MOTOROLA 1N5231B	D2.D3
4	2		18-01-421	RES. 2.0K 1/4 WATT 1%	R2.R3
3	1/6		16-20-053	HEADER, .025" SQ, SULLINS, PZC36SFAN (36_PIN)	P1
2	1		16-04-061	JACK, TOP ENTRY PCB MODULAR, 4 CONTACTS, BERG 69253-001	P2
1	1		26-04-845B	BARE PCB, PC-845B	31217
ITEM NO. QTY FSCM RECD NO. PART OR IDENTIFYING NO. NOMENCLATURE OR DESCRIPTION					

PARTS LIST

SCALE	SIZE	DWG. NO.	REV
NONE	B	31213	C
SHEET	1 OF 2		

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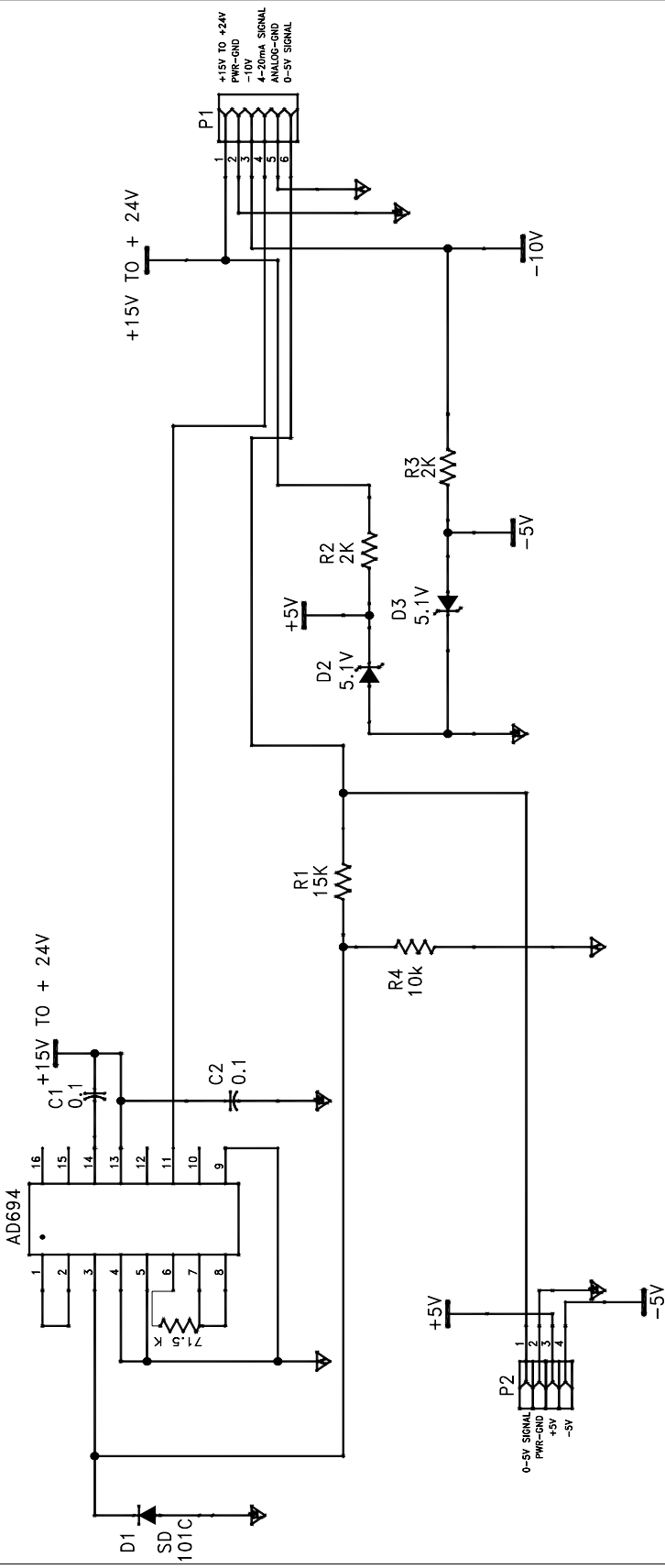
ASSEMBLY DIAGRAM
PC-845 ASSY

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CHECKED T. QUINN 1/97

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 FRACTIONS ARE DECIMALS ANGLES
 .XX.01 2
 + 1/64 .XXX.005 2"

U1 (SEE NOTE 2 ON SHEET 1)



ASSEMBLY DIAGRAM
 PCB 845

DRAWN R.B.MILLER 1/97
 CHECKED T. QUINN 1/97

SCALE NONE
 SHEET 2 of 2

SIZE B

REV 31213C

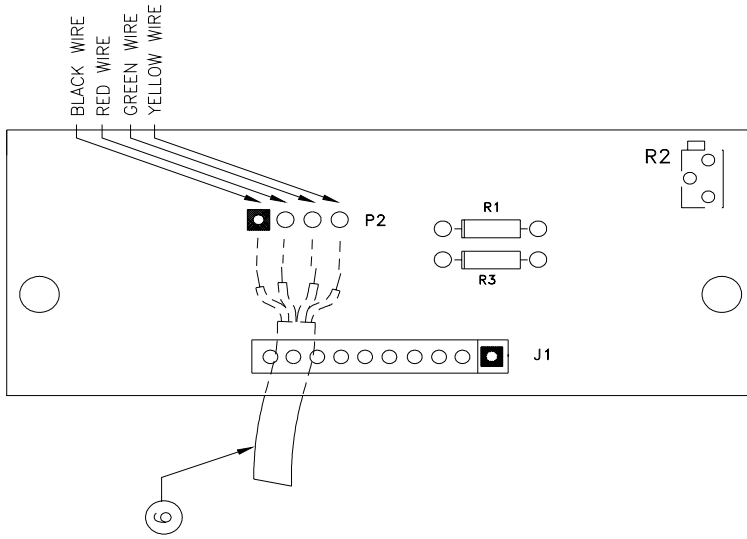
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DIMENSIONS ARE IN INCHES
FRACTIONS .XXX, .01
1/64 .XXX±.005

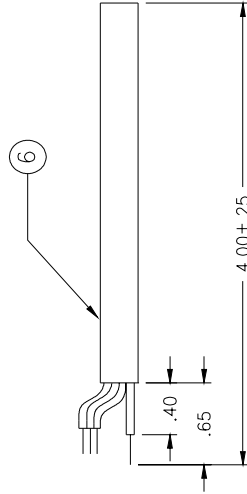
ITEM(S) 65-750

REVISIONS

REV	DESCRIPTION	ISSUED BY
A	INITIAL ISSUE	RAO 2/7/97



1. ASSEMBLE AND CLEAN BOARD IN ACCORDANCE WITH IPC-A-610, CLASS 2 STANDARDS.
2. STRIP AND TIN LINE CORD (ITEM #6) AND INSTALL ON THE SOLDER SIDE OF THE PCB AS SHOWN.
3. DO NOT SOLDER ANY OF THE JUMPERS ON THE PCB.



CABLE PREPARATION

6	4"	15-05-021	LINE CORD, STRAIGHT 4 COND BLACK
5	1	19-05-084	POT. 20K 1/4" MULTITURN, SIDE ADJ. BOURNS 3266X-1-203
4	1	18-01-454	RES. 24.9K 1/4W 1% AXIAL LD STYLE RN-55+/-100PPM/C
3	1	18-01-371	RES. 1.15K 1/4W OR 1/8W 1% AXIAL LD STYLE RN-55+/-100PPM/C
2	1/3	16-52-002	SOCKET, .36 POSITION BREAK AWAY FEMALE, 3M 929850-01-36
1	1	26-04-846A	BARE PCB, PC-846A

ITEM NO.	QTY	FSCM NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	REF/DWG NO.
1	1			BARE PCB, PC-846A	31218

PARTS LIST

SCALE	SIZE	DWG. NO.	REV
NONE	B	31214	A

ASSEMBLY DIAGRAM
PC-846 ASSY

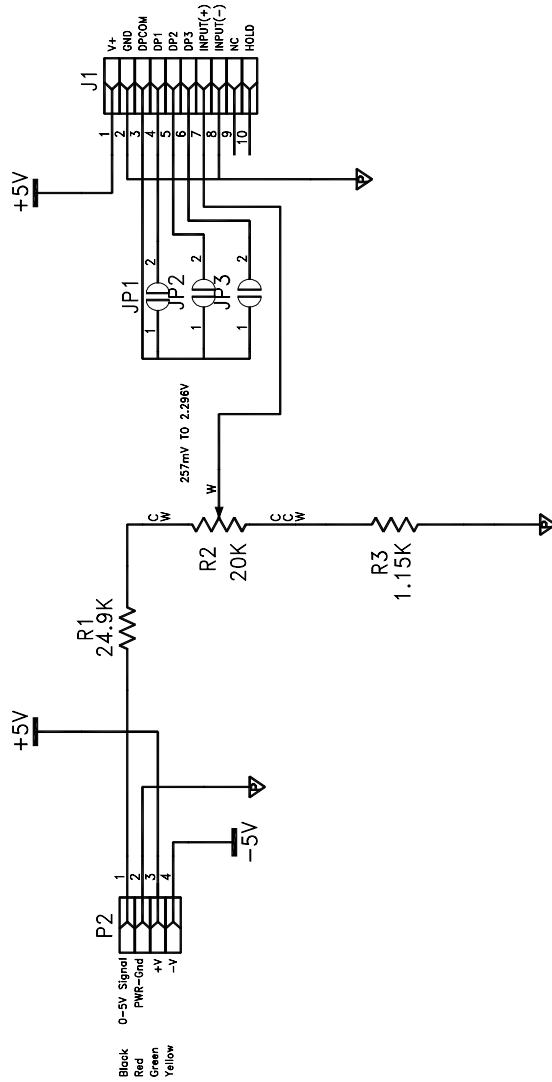
DRAWN R.B.MILLER
CHECKED T. QUINN

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DIMENSIONS ARE IN INCHES
FRACTIONS DECIMALS ANGLES
* .XX2 01 * 2'
1/64 .XXX .005



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ASSEMBLY DIAGRAM
PCB 846

DRAWN R.B.MILLER
CHECKED

SCALE NONE
SHEET 2 of 2

SIZE DWG. NO. **B 31214**
REV **A**